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National
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Center

International Energy Biweekly Review

1 November 1978

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INTERNATIONAL ENERGY BIWEEKLY REVIEW

1 November 1978

Overview	1
Iranian crude oil production and exports have been seriously disrupted by widespread strikes. The cutbacks are introducing new pressures into an already tightening world oil market.	
Iranian Strikes: Impact on World Oil Market	3
Recent crude oil output in Iran was down to about 1.5 million b/d	
For a variety of reasons, most underutilized productive capacity outside of Iran will not be immediately available as a substitute for Iranian oil. Prolonged strikes will have a severe market impact, and OPEC price hawks will be encouraged to hold out for a substantial price increase.	
Israel: Energy and the Return of the Sinai	13
With the return of the Sinal oilfields to Egypt, Israel will remain totally dependent on oil imports for the next several years. Tel Aviv probably will try to negotiate access to at least some Sinal oil and gas.	
Japan: Reaffirming Links with the Middle East	27
Prime Minister Fukuda's September trip to the Middle East highlighted Japan's continuing effort to maintain good economic and political relations with its Middle East oil suppliers. While the trip was a diplomatic success, no significant new economic or energy commitments were made.	
Sweden: Road Cleared for Further Nuclear Development	33
The replacement of the Center Party by the new Liberal Party government opens the way for accelerated progress on Stockholm's nuclear power program.	
Sweden: Energy Conservation	37
Increased energy prices provided the main impetus to conservation. Energy consumption in Sweden in 1976 was 1 million b/d of oil equivalent, 4 percent below what it would have been if pre-embargo trends in energy efficiency had continued. Energy savings were, however, lower relative to total energy consumption than in most major foreign countries.	

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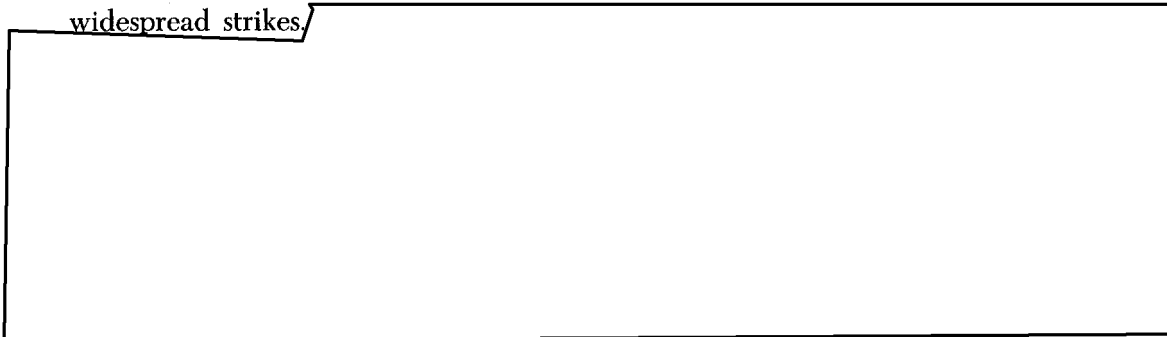


INTERNATIONAL ENERGY BIWEEKLY REVIEW

Overview

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Iranian crude oil production and exports have been severely disrupted by widespread strikes.



The government has attempted to satisfy striking workers by granting wage and benefit hikes as high as 50 to 100 percent, but its conciliatory attitude has only led to walkouts by additional workers. A full settlement does not appear imminent.

Oil inventories among non-Communist countries currently are in good shape, with stocks amounting to about 74 days of normal consumption as of 30 September 1978.

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The cutbacks in Iran, however, compound an already strained supply situation resulting from a surge in demand in anticipation of a yearend price increase by OPEC. Increases in output from Saudi Arabia, Iraq, and other producers in OPEC probably would have accommodated the increase in demand, but the Iranian export cutback introduces new pressures into the market.

Even if the strike is relatively short lived, the impact will spill over at least into first quarter 1979 by keeping demand for OPEC oil high. The tightening of the oil market will also encourage the price hawks at the December OPEC meeting. If the strike is sustained, the market impact will be severe. Spot prices for oil will rise further and supply shortages could develop. Even so, and even if other OPEC deliveries are not increased, a shutoff of all oil exports from Iran would have to continue unabated for about six months to produce the same loss of oil on the world market as during the 1973/74 embargo.

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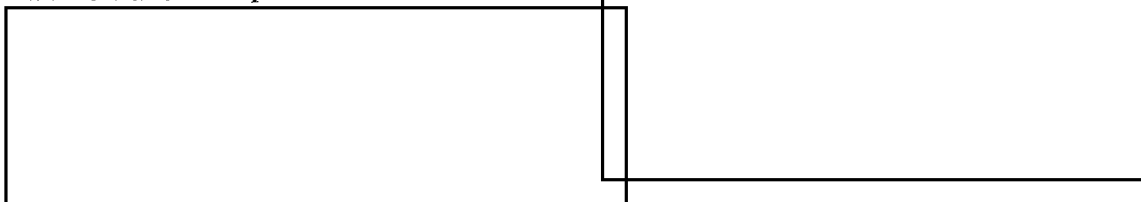
IRANIAN STRIKES: IMPACT ON WORLD OIL MARKET

Situation in Iran



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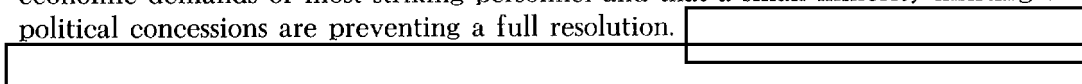
The most severe labor problems are in the oilfields, where all rank and file workers and staff personnel are now on strike.



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Various groups of employees of the state-owned National Iranian Oil Company (NIOC) have participated in the strikes over the past several weeks. Settlement of a strike by blue collar workers was followed by a walkout by office workers and marine pilots at Kharg Island. The marine pilots settled their strike, but production workers at several major oilfields took up the cudgel. The government's response to strikers in the oil and other sectors has been uniformly conciliatory in an effort to avoid increasing the ranks of those in opposition to the Shah. But wage and benefit hikes as high as 50 to 100 percent given to some groups have encouraged additional workers to stage walkouts.

Government negotiator and NIOC chairman Ansary believes he has satisfied the economic demands of most striking personnel and that a small minority insisting on political concessions are preventing a full resolution.



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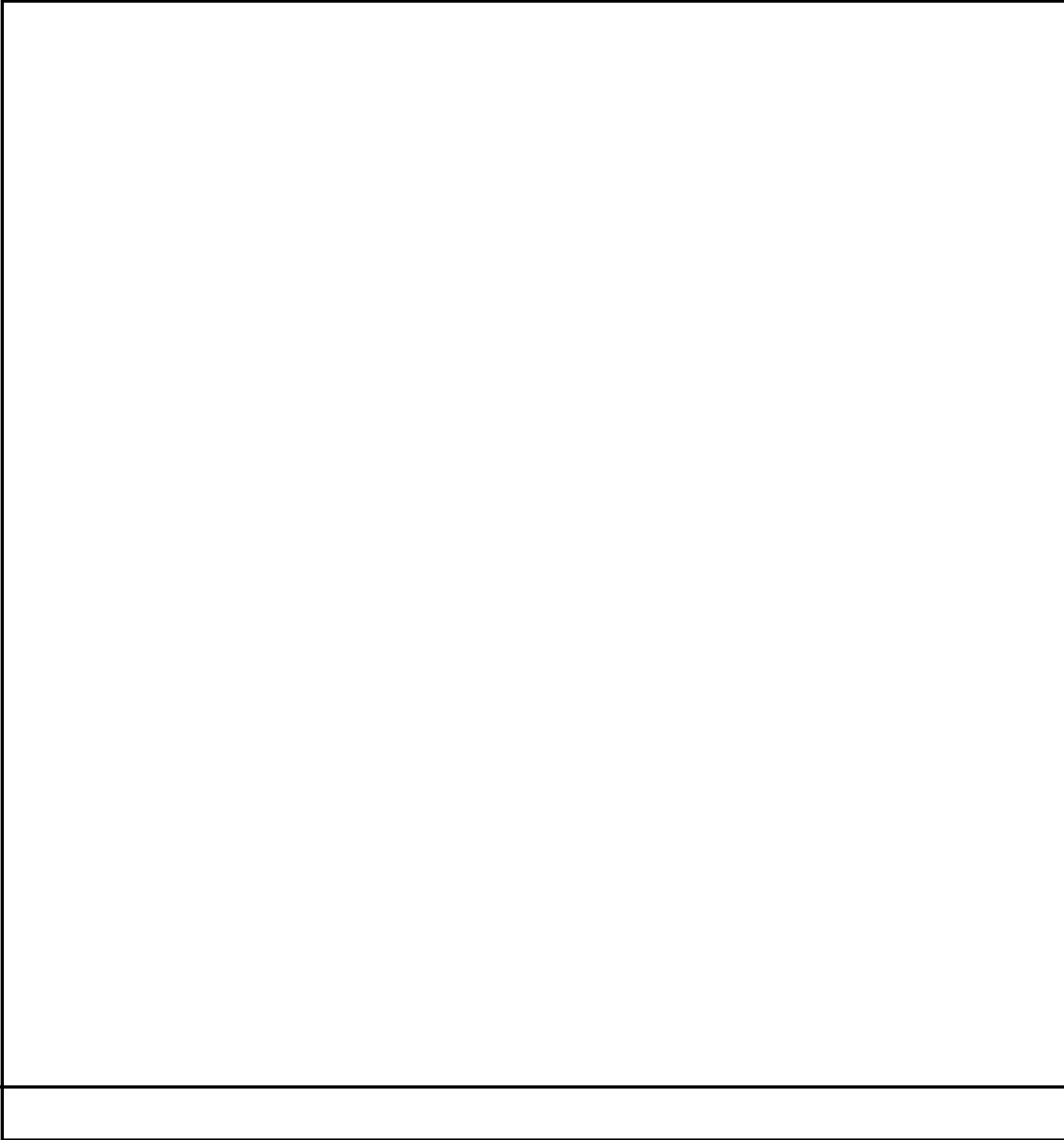
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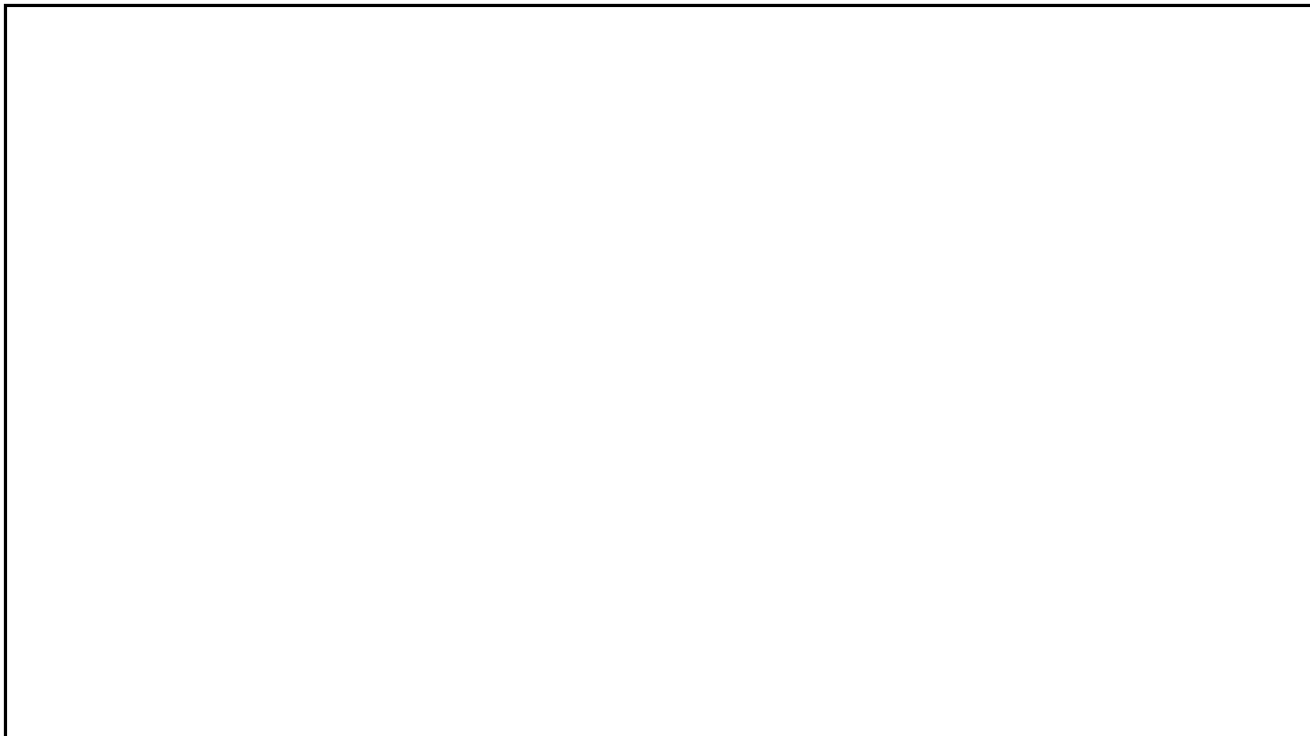
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Demand

The oil market was tightening even before the Iranian problems became apparent. Preliminary reports in October had spot tanker charterings at near-record levels. Demand for OPEC oil (including natural gas liquids) in the fourth quarter was expected to average about 33 million b/d, up from 30.5 million b/d in the third quarter and 29 million in first-half 1978. This increased demand reflects normal seasonal increases along with increased purchases in anticipation of a yearend OPEC price increase.

Demand for OPEC oil in 1979 is tentatively projected to increase by 1 million to 2 million b/d over average 1978 levels—to about 32 million b/d. This estimate assumes a 3-percent increase in Free World oil consumption, a normal stock buildup, continuation of US and Japanese imports for strategic stockpiles, and an increase of about 1 million b/d in non-OPEC supplies, primarily from the North Sea and Mexico.

Stocks

Free World oil stockpiles at the end of third-quarter 1978—some 3.8 billion barrels—were slightly less than at the end of September 1977 and represented 74 days

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of normal consumption.

Reduced Iranian Supplies: Impact on the Market

The loss of Iranian oil exports will further tighten the short-term oil market, encourage OPEC hawks to hold out for a substantial price increase, and produce sharp increases in the price of oil traded in world spot markets. Spot market prices were rising already; they spurted when the first news of the Iranian cutbacks reached the market. If experience during the 1973/74 embargo holds true, the rate of increase will grow sharply if the Iranian strike lengthens and the scramble for oil supplies intensifies. In the near term, however, the market activity will reflect speculative buying more than real shortages because Free World oil inventories are currently in good shape.

Even if the strike is relatively short-lived (for example, a settlement is reached in the next week or two), the impact will spill over into at least first-quarter 1979. Prior to the Iranian problems, demand for OPEC oil was expected to fall off in the first quarter as oil companies worked off inventories built up during the pre-price increase period. Now many buyers will have a harder time purchasing desired quantities of oil in the fourth quarter. They also will be reluctant to draw down inventories in first-quarter 1979 if, as expected, the uncertainty in Iran continues.

If the strike is sustained, with Iranian oil exports curtailed beyond Thanksgiving and other OPEC suppliers unwilling or unable to make up the gap, the market impact will be severe. On the other hand, even if other OPEC deliveries are not increased, a complete shutoff of oil exports (crude and products) from Iran—about 5.2 million b/d during September 1978—would have to continue unabated for more than six months to produce the same total loss of oil to world markets as during the 1973/74 embargo.

During the October 1973-April 1974 Arab oil embargo, slightly more than 1 billion barrels of oil, or about 4.7 million b/d, were withheld from the market. At the peak of the crisis in December, oil output in countries actually participating in production cutbacks * was 13.1 million b/d, 5 million b/d below the September 1973 rate. Iran was the only non-Arab producer able to boost output during the supply interruption; by yearend, it posted a gain of 300,000 b/d over the preembargo level. Although Arab production restrictions were eased beginning in January 1974, it was not until May that OPEC production was back to near preembargo levels.

* Dubai and OPEC members, except Bahrain and Iraq.

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In some respects, oil consuming countries are better prepared to withstand a supply interruption similar to the embargo. For example, oil stocks measured in days of consumption are higher now than in 1973 and the International Energy Agency (IEA) has set up an oil-sharing scheme.* Company experience in dealing with the embargo is also a positive factor.

On the other hand, the ability of the major consuming countries to easily reduce oil consumption is probably less now than during the embargo. During fourth-quarter 1973 and first-quarter 1974, the major oil-consuming countries reduced consumption by about 5 percent compared with year earlier levels; oil inventories were actually higher at the end of the 1973/74 embargo than at the beginning. Thus, the widespread conservation measures that major consuming countries have implemented since 1973 have already realized the easiest savings.

Major Importers of Iranian Oil, 1977

	Thousand b/d		Imports as a Percent of Consumption
	Consumption ¹	Imports from Iran	
South Africa	300 ²	240	80
Israel	135	100	74
Netherlands ³	745	270	36
Spain	943	220	23
Japan	5,401	870	16
Italy	1,893	293	15
United Kingdom	1,809	259	14
France	2,286	189	8
United States	18,418	786	4

¹ Including bunkers.

² Estimated.

³ The Netherlands is a large oil export refining center. Imports from Iran as a share of total supply amounted to about 20 percent in 1977.

Moreover, as in 1973/74, the supply shortfall is occurring when oil stocks are normally drawn down to meet high winter oil consumption. During the October-March period, oil consumption is normally about 3 million to 4 million b/d higher than during the rest of the year. A particularly cold winter would exacerbate the problem, and a rapid stock drawdown probably would result in spot shortages,

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particularly for heating oil. In sum, a cold winter combined with a prolonged supply shortfall would have a potentially serious impact both politically and economically.

The countries with the heaviest import dependence on Iranian oil, South Africa and Israel, have sizable oil stockpiles, especially South Africa. Other importing countries with a high dependence on Iranian oil include Spain, the Netherlands, Japan, Italy, and the United Kingdom.

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ISRAEL: ENERGY AND THE RETURN OF THE SINAI

The prospective return of Israeli-controlled Sinai territory to Egypt would keep Israel almost totally dependent on imported oil for its energy needs at least for the next several years. An oil-producing area discovered last year off the Israeli-controlled portion of the Sinai, although it will only save Tel Aviv \$20 million in foreign exchange in 1978, could have supplied most of the country's oil needs by the first half of the 1980s and have saved about \$500 million a year in foreign exchange. A recently found gas deposit in the northern Sinai could have more than filled Israel's current industrial demand for natural gas.

Under the terms of a peace treaty, Tel Aviv may have to pay some type of reparation to Cairo for the 2.9 million barrels of oil extracted thus far this year. Israel might claim a right to share the area's mineral resources because of its discovery and exploration efforts. Egypt, on the other hand, consistently has protested—with formal US support—that Israeli development of natural resources in occupied territory is illegal. In any event, Tel Aviv probably will try to negotiate access to at least some of the Sinai's mineral resources because Egyptian supplies would be cheaper than buying from other, more distant, suppliers. Moreover, oil purchases from Egypt would be symbolic of a major change in political relationships.

Even if Tel Aviv makes a deal with Cairo and thus starts to import much of its oil from the Sinai, any future cutoff of Gulf of Suez oil would not pose a major security problem. Substitute supplies probably could be obtained elsewhere, most likely from Iran and Mexico—major current suppliers. Even if there were some difficulty in setting up new supply lines, Tel Aviv could operate for at least seven months by rationing oil in stock.

Over the longer term, Israel is searching for various alternatives to reduce dependence on oil imports. Coal-fired electrical generating plants already are under construction and should provide about 40 percent of Israel's electrical power needs by 1983. Other efforts such as government support for a conservation policy to moderate energy consumption and funding of research and development of nonoil energy sources are not likely to bring about a major reduction in oil demand before the late 1980s.

The Sinai Stake

The capture of the Sinai oilfields in the 1967 war with Egypt was a boon to the Israeli economy. Egypt had been producing 90,000 b/d from the Abu Rudays and other Sinai fields. After pumping at less than half this rate for several years, output

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under Israeli control reached 100,000 b/d in 1974 which made Israel almost self-sufficient in oil. After the 22 September 1975 Sinai II accord, which entailed the return of all producing fields to Egypt, Tel Aviv began an intensive exploration program in the remaining Israeli-controlled parts of the Gulf of Suez and the northern Sinai. This effort culminated in 1977 with oil and gas strikes of commercial size; oil production in the Gulf began in November 1977, but gas exploration awaits completion of a pipeline scheduled for next summer.

With the return of the Sinai to Egypt, Israel will remain almost totally dependent on imports of oil for energy supplies until the early 1980s. At present less than 2 percent of energy demand is filled from sources within Israel proper. Domestic gas and oil production is equivalent to only about 2,000 b/d of oil. The domestic oilfields, moreover, are almost depleted, and gas production probably will decline significantly in the next two years; a small amount of solar energy is used for hot water heating.

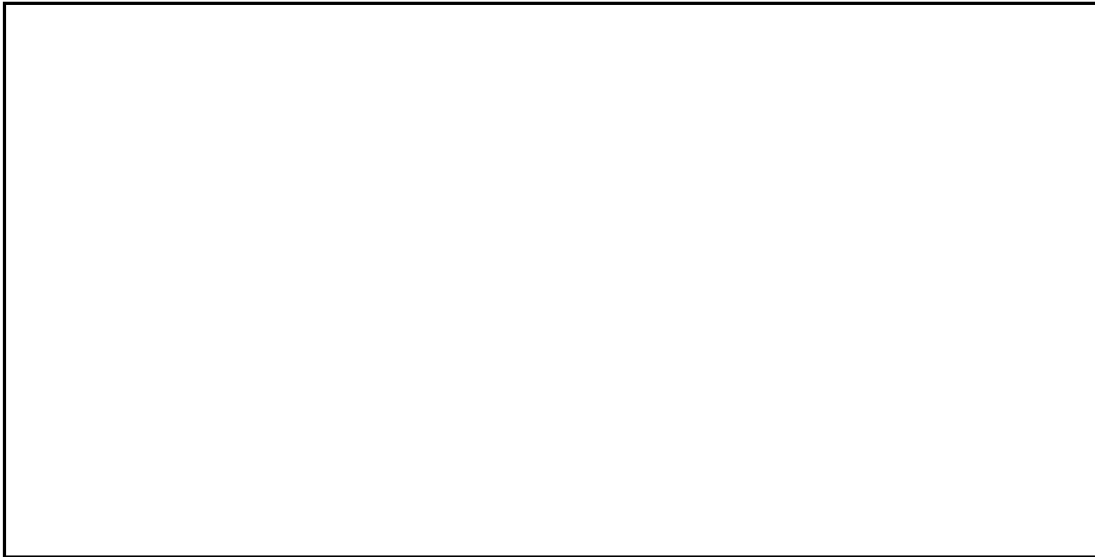
Israel: Energy Supply and Demand

	Thousand b/d Oil Equivalent									
	Estimated			Projected						
	1970	1977	1978	1979	1980	1982	1982	1983	1984	1985
Energy consumption	104	135	142	153	164	175	187	200	214	229
Oil and gas	104	135	142	153	154	164	155	157	171	186
Coal	0	0	0	0	11	11	32	43	43	43
Energy supplies	104	135	142	153	164	175	187	200	214	229
Domestic oil and gas	4	2	2	1	1	1	1	1	1	1
Sinai oil and gas ¹	45	0	15	0	0	0	0	0	0	0
Oil imports	55	133	125	151	152	163	154	156	170	185
Coal imports	0	0	0	0	11	11	32	43	43	43

¹ After 1978, Sinai production is assumed to revert to Egypt; potential Sinai output could provide the following Israeli imports in thousand b/d oil equivalent:

	1979	1980	1981	1982	1983	1984	1985
Gulf of Suez oil	55	85	115	145	150	150	150
Sinai gas	2	4	4	4	4	4	4

Tel Aviv's remaining energy needs in 1978 are being provided by crude imports of 125,000 b/d mostly from Iran and Mexico and by 15,000 b/d from the recently discovered Alma field in the Gulf of Suez. About half of the imported oil is converted to heavy fuel oil, largely for electricity generation. Two refineries with a combined capacity of 180,000 b/d produce almost all of the fuel oil and other oil products needed. Both of these refineries are equipped to process high-sulfur crudes and can, in fact, use most of the common crudes available worldwide.



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Israel: Energy Consumption

Thousand b/d Oil Equivalent

		Domestic oil, gas and solar	142	2
2	135			
	20	Mexican oil	25	
	100	Iranian oil	100*	
Other oil imports	13		15	Gulf of Suez
	1977		1978	

*Includes a small amount from other sources.

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* Oil ranges from 30° API with 1.7 percent sulfur to 32.5° API with less than 1 percent sulfur; oil of this quality sells at between \$12.00 to \$12.50 per barrel on the open market.

1 November 1978

SECRET

15

25X1

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JAPAN: REAFFIRMING LINKS WITH THE MIDDLE EAST

This article is the first in an aperiodic series on economic and political relations of major oil importers with their Middle East suppliers.

Prime Minister Fukuda's visit to Iran, Saudi Arabia, the United Arab Emirates (UAE), and Qatar in September reflects Japan's continuing effort to maintain good relations with the Middle East, the region that supplies 75 percent of Japanese crude oil needs. While the trip was a diplomatic success, neither Fukuda nor his hosts made any significant new economic or energy commitments.

Japan's Approach

Fukuda used his Middle East trip—the first ever by an incumbent Japanese Prime Minister—to demonstrate high level interest in Japan's substantial stake in the Middle East. Japan's diplomacy toward the Middle East has matured considerably since its initial scramble to secure oil supplies in the wake of the 1973 oil embargo and subsequent oil price hikes. Then Tokyo quickly dispatched several high-ranking delegations to the oil-producing states to offer aid and technical assistance in the hopes of winning supply guarantees. Since that time, Tokyo has pursued a more measured and calculated approach to further its economic interests in the region.

Japan's oil needs, combined with the attraction of the lucrative Middle East market, produced a quadrupling in Japanese trade with the region between 1973 and 1976. Japan now provides roughly 10 percent of the region's imports. The Middle East purchases some 12 percent of Japan's worldwide exports, primarily heavy industrial

Japan: Oil Imports, January-June 1978

	Thousand b/d		
	Crude	Products	Total
Imports	4,751	649	5,400
Middle East	3,587	358	3,945
Saudi Arabia	1,549	174	1,723
Iran	883	37	920
Kuwait	424	98	522
United Arab Emirates	456	11	467
Iraq	153	1	154
Qatar	110	0	110
Algeria	6	0	6
Libya	6	0	6
Bahrain	0	37	37
Indonesia	621	60	681
China	129	0	129
Other	414	231	645

1 November 1978

SECRET

27

SECRET

goods and textiles, compared with less than 5 percent in 1973. More than 80 percent of Japan's trade in the region is conducted with its primary oil suppliers—Saudi Arabia, Iran, Kuwait, the UAE, and Iraq.

Tokyo's only official oil agreement—involving an Iraqi guarantee to supply 180,000 b/d of crude oil over 10 years in return for \$1 billion in commercial and official credits from the Japanese for Iraqi development projects—has proved unsatisfactory to both sides. Japan's failure to meet its promised oil import levels from Iraq in 1975, the complexities of dealing with the Iraqi Government, and the resultant Japanese reluctance to commit funds to specific Iraqi development projects under the agreement, have convinced both countries that any future oil supply arrangements would have to be more flexible and less costly. Another official agreement, with Iran, has also been disappointing to Tokyo. Japan's sizable financial commitment to several Iranian development programs has failed to produce any flexibility from Tehran on the price of Iranian oil.

Japanese Government officials now give clear priority to private sector dealings over government-to-government economic arrangements. Tokyo has used tax incentives and official insurance guarantees to stimulate several large-scale private investment projects. It has also encouraged the flow of Japanese capital toward its primary oil suppliers; Saudi Arabia, Iran, Iraq, and other Persian Gulf states account for about 75 percent of roughly the \$1.5 billion in direct Japanese fixed investment in the Middle East.

Several Japanese companies are engaged in oil production and development in the Middle East. Although operations are small, the Middle East accounts for 60 percent of the more than \$4 billion spent by the Japanese in overseas oil exploration and development over the last two decades. The most successful all-Japanese operation

Japan: Overseas Oil Producers Operating in the Middle East

Operating Company	Japanese Participant (Percent Ownership of Operating Company)	Country	Fields	1977 Crude Oil Production (Thousand b/d)	1977 Shipments to Japan (Thousand b/d)
Abu Dhabi Oil Co.	Daikyo Oil Co. } Maruzen Oil Co. } (76%) Nippon Mining Co. } Other Japanese interests (24%)	Abu Dhabi	Mubarras	20	20
Arabian Oil Co.	Arabian Oil Co. (100%)	Saudi Arabia-Kuwait Neutral Zone	Khafji, Hout	170	100
Abu Dhabi Marine Areas	Japan Oil Development Co. (12%)	Abu Dhabi	Zakum, Umm Shaif	520	195
Al-Bunduq Oil Co.	United Petroleum Development Co. (33.3%)	Abu Dhabi/Qatar	Al Bunduq	20	20

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has been run since 1958 by the Arabian Oil Company, which works in the Saudi-Kuwaiti Neutral Zone and produced 170,000 b/d of crude oil in 1977. Japan's largest single outlay for an overseas oil venture—\$780 million—was spent in 1973 to purchase part of a British share in a producing concession in Abu Dhabi that now produces about 520,000 b/d. Some 335,000 barrels of crude per day were shipped to Japan in 1977 from Middle East fields that Japanese companies operate in whole or in part.

Although Japan's policy focuses on the oil producers, Tokyo has also undertaken some modest initiatives to enhance relations with other Middle East states. Encouragement from both the Arabs and the United States has prompted Tokyo to increase its assistance to Egypt over the past year. Fukuda had intended to visit Cairo but canceled because of the Camp David talks; instead, Tokyo announced a new loan of \$160 million to Egypt for commodity assistance in 1979. At Saudi suggestion, Tokyo is exploring a joint venture with Saudi Arabia to assist Sudan. The Japanese are also examining the establishment of a Japanese-Arabian cultural center to be built in Cairo.

Fukuda's Trip

Fukuda ostensibly achieved his political objectives during his visit to Iran, Saudi Arabia, the UAE, and Qatar. He established personal relationships, reasserted Japan's pro-Arab position on Middle East issues, and emphasized Japan's willingness to cooperate in the economic development of the region, especially in the four countries visited. Most of all, the trip boosted his stock at home, where he faces a general election toward the end of the year.

On the economic front, Tokyo is clearly concerned about protecting its share of Middle East markets. Last year Japanese industrial plant exports to the Middle East plummeted by 36 percent to \$1.8 billion, in large part because of increased competition, appreciation of the yen, and a general weakening in demand. But, Fukuda probably did not seek any special treatment from his hosts, particularly since the main thrust of his trip was to emphasize Japan's willingness to be helpful. On the other hand, he asked for and received Arab and Iranian assurances of "reasonableness" in OPEC price deliberations.

- In *Saudi Arabia*, Fukuda promised that if a feasibility study proves encouraging, the Japanese Government would vigorously promote the proposed Saudi-Japanese petrochemical project at Jubail as a "national project." This designation would allow the Japanese Government to participate in the consortium and extend loans. The Jubail project has been a sore point with the Saudis since 1976 when Mitsubishi suspended preparations for its implementation because of skyrocketing construction costs and questionable world demand for petrochemicals. The company feared a \$500 million

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loss during the first decade of the plant's operation. Although Japanese companies have succeeded in winning Saudi contracts for a number of projects—such as cement plants, desalination facilities, and electric power plants—they have been slow to fulfill promises they made shortly after the oil embargo to participate in a number of other major projects, including a large oil refinery and a steel mill, as well as the petrochemical plant.

- In *Iran*, Fukuda engaged in general discussions focusing on the terms of Japanese financing for the \$2 billion Kalingas liquefied natural gas (LNG) project. The Japanese hold a 48 percent equity share in a consortium that will operate Kalingas. Under consideration since 1974, Kalingas is to supply Japan with 2.6 million tons of LNG annually for 20 years starting in 1982. A liquefaction plant construction contract has been signed, but the date for beginning construction has not yet been set. The Japanese are involved in two other major projects in Iran: a \$3 billion petrochemical complex under construction at Bandar Shahpur and a \$2.5 billion export refinery, which is still in the planning stage.

Iran unsuccessfully pressed Fukuda to buy more of its oil. Tehran wishes to maintain output at full capacity because of its revenue needs. But output has been well below capacity this year and Tehran has been frustrated by a steady decline in its share of Japanese oil imports from a preembargo level of 32 percent to 16 percent in 1977, while the Saudi share has grown from 24 percent to 32 percent during the same period.

- Fukuda's visit to the *United Arab Emirates* coincided with the signing of a joint agreement for the development of the small Umm Al Dalkh offshore oilfield. The Japan Oil Development Company (JODCO) and the Abu Dhabi National Oil Company (ADNOC) are 50:50 partners in the venture, which is expected to yield 50,000 b/d of crude. More importantly, both companies plan multibillion-dollar expansion of productive capacity at the giant Zakum offshore oilfield. The Japanese also are involved in an LNG project on Das Island, which has been in operation since May 1977. Fukuda promised economic cooperation in a number of other projects, including desalination plants and development in agriculture and the fishing industry.

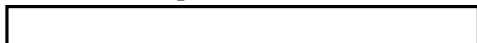
- In *Qatar*, he agreed to the formation of a joint committee of experts and technicians to discuss Qatar's economic development and the role Japan can play. The Emir asked for Japanese participation in natural gas development, while Fukuda offered cooperation in Qatar's desalination project. The Japanese currently are not involved in any major economic project in Qatar.

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Fukuda's itinerary excluded Kuwait and Iraq, two major suppliers of oil to Japan. Japanese companies are heavily involved in construction work in Kuwait and are known for their promptness in completing projects. One of the largest is a desalination/electricity generation complex.

Tokyo reiterated its interest in Iraq in early 1977 by agreeing to double the size of government credits to a total of \$2 billion. Thus far, a \$300 million chemical fertilizer plant is under construction, and \$200 million has been committed for a thermal power station at Hartha. Other possible projects for the remaining credits include a petrochemical plant, natural gas concentration plant, oil refineries, and liquefied petroleum gas (LPG) plant.

Although Japan is pushing energy exploration elsewhere in the world and is actively examining ways to boost alternative energy sources, Tokyo will continue to rely on the Middle East for a major share of its energy supply for the foreseeable future. Given that dependence and the general recognition among the Japanese that there are few options available to further underwrite the security of their stake in the region, Tokyo is unlikely to reduce its emphasis on its important economic ties with the Middle East. The Japanese will continue to focus on stimulating private sector involvement in bilateral dealings with the oil producers, while maintaining a low but constructive posture toward the more basic questions of security in the region.



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SWEDEN: ROAD CLEARED FOR FURTHER NUCLEAR DEVELOPMENT

The departure of the Center Party from the Swedish Government clears the way for accelerated progress on Stockholm's nuclear power program. Former Prime Minister Falldin led his party out of the three-party coalition—the first nonsocialist government in four decades—because he could not fulfill the party's 1976 promise to stop all nuclear power development in Sweden and eventually to dismantle those reactors already in operation. The new government, formed by the small Liberal Party, favors nuclear development, as do the other major Swedish parties. Despite its problems during Falldin's tenure, the nuclear industry did not scale down its capabilities; it is primed for the construction and operation of the remaining reactors envisioned under a 1975 plan.

Nuclear Politics

In 1975 Olaf Palme's Social Democratic government, seeking to combat the high cost of imported energy and to spur economic growth, adopted a program designed to triple nuclear power production by 1985. Nuclear power was already well established in Sweden, and it appeared to offer the best hope for expanding indigenous energy sources since hydroelectric potential was limited and Sweden possessed no fossil fuels except peat.

By late 1977, however, the nuclear program was meeting strong resistance. Continued recession suggested that earlier estimates of future electric power needs were too high. Falldin—who felt he had a clear mandate from the voters to curb the nuclear industry—imposed stringent waste disposal requirements that led to delays in startup of completed reactors. His coalition partners went along with that measure but not with Falldin's basic strategy of postponing decisions on nuclear expansion and hindering operations of new facilities. Compromise became a way of life in dealing with nuclear issues.

The disagreement on basic strategy, however, proved too deep to remain submerged indefinitely. In the days before his resignation, Falldin accepted a compromise on technical conditions for the startup of two new reactors. To his dismay, the Moderate Party—which was the third partner in his coalition—publicly interpreted the move as a victory for nuclear development. The even more sensitive question of funding another reactor still in the development stage was looming. Foreseeing a pre-election year of repeated policy crises that would result either in further expansion of the nuclear industry or in his forced resignation at a time too late to protect his party's credibility, Falldin opted to resign immediately.

1 November 1978

SECRET

33

SECRET

Energy Trends

A substantial shift toward nuclear power has taken place in Sweden in the last few years. Energy consumption increased by only 3 percent between 1973 and 1977, thanks to a combination of conservation and low economic growth.* In 1973, the nuclear contribution was only three percent. By 1977 nuclear plants were generating

Sweden: Electricity Generation by Source

	Percent			
	1973	1977	1985	1990
Hydroelectric	77	60	52	49
Nuclear	3	22	36	42
Thermal	20	18	12	9
Total	100	100	100	100

about 22 percent of all electricity produced and satisfying about 9 percent of total energy demand. Hydropower still generated about 60 percent of Swedish electricity in 1977, but its share of total production has been falling since 1973. The expansion of nuclear power apparently has also permitted a small reduction in the use of oil-burning power plants.

According to government projections, nuclear power will supply over 40 percent of Sweden's energy in 1990. Dependence on oil will decline markedly and the volume of oil imports is expected to be 16 percent less in 1990 than in 1978 if the nuclear

Sweden: Total Primary Energy Requirement

	Percent			
	1973	1977	1985	1990
Oil	60.1	56.0	47.2	36.9
Hydroelectric	28.7	24.5	24.6	24.2
Solid fuel	10.1	10.3	10.8	16.4
Nuclear	1.0	9.2	17.3	20.7
Other	0.1	0	0.1	1.8
Total	100	100	100	100

program is fully implemented. Coal imports will grow, and use of domestic wood and peat supplies will increase. Hydroelectric production is expected, at best, to maintain its relative share of the energy supply even with the addition of new capacity; two-thirds of the hydroelectric potential has already been exploited.

* See following article for a discussion of energy conservation in Sweden.

SECRET

Outlook for Nuclear Power

Falldin's departure probably removes the only serious threat to completion of Sweden's nuclear power program. Of the 13 reactors envisioned under the 1975 plan, eight have been completed, including the two awaiting government permission to load fuel. The commitment to nuclear development of Palme's Social Democrats—likely to be returned to power in the next general election—has not diminished. Moreover, popular support for nuclear power has grown dramatically in the last two years and the majority of the population now favors development of nuclear power.

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1 November 1978

SECRET

35

SECRET

SWEDEN: ENERGY CONSERVATION

This is a supplement to our series of analyses on energy savings in the major foreign countries. Sweden was selected because of its reputation as an energy efficient country.

Energy consumption in Sweden in 1976 was 1 million b/d of oil equivalent, 4 percent below what it would have been if pre-embargo (1969-73) trends in energy efficiency had continued. Increased energy prices, reflecting higher costs and taxes, have provided the main impetus to conservation. Despite Sweden's reputation for being energy conscious, however, government conservation measures were implemented slowly, and energy savings in Sweden were lower relative to total energy consumption than in most major foreign countries in 1976.

Sweden: Energy Consumption by Sector, 1976

	Total	Industry	Transportation	Residential/ Commercial, Public Services, and Agriculture	Energy *
	Thousand b/d of oil equivalent				
1969-73 consumption trend					
extrapolated	1,060	365	115	315	265
Growth-adjusted consumption	1,075	320	115	330	310
Actual consumption	1,028	310	113	295	310
Implied savings	47	10	2	35	0
	Percent				
Savings as a share of growth- adjusted consumption	4.4	3.1	1.7	10.6	0

* Including bunkers and statistical difference.

Preembargo Efficiency Trends

Energy consumed per unit of industrial production increased at an average annual rate of 0.5 percent in 1969-73 reflecting a structural shift in output toward more energy-intensive products. During 1969-73, for example, output in the pulp and paper and chemical industries rose at average annual rates of 6.5 and 8.0 percent respectively, compared to the 4.9 percent increase for all industry. The pulp and paper industry accounts for about 40 percent of industrial energy used in Sweden. In contrast, output in another energy-intensive industry, steel, rose at an average annual rate of only 2 percent.

SECRET

Energy consumed per dwelling unit increased at an average annual rate of 1.9 percent in 1969-73. This trend reflected a sharp rise in real disposable income which encouraged the Swedes to make wider use of electrical appliances.

During this period energy used per registered motor vehicle declined slightly. It is not clear if this change resulted from an improvement in automobile efficiency or a reduction in miles driven per vehicle. Data on such trends are not available.

Post Embargo Planning

Dependent on imports for two-thirds of its energy consumption, Sweden began promoting energy conservation after the 1973 embargo, and a major energy program was passed by Parliament in May 1975. This program called for the annual growth of energy consumption to fall to 2 percent by 1985; zero growth was established as the goal for 1990. The program's conservation measures were directed mainly at the residential and industrial sectors; Stockholm increased the funds available for conservation incentives and for energy research and development programs; it raised energy taxes; and it passed new conservation legislation.

Energy conservation was given even more priority after 1976 as opposition intensified to nuclear energy as an alternative to imported oil for electricity generation. In late 1976 popular concern about waste disposal, safety, and environmental problems associated with nuclear energy development contributed to the ouster of the Social Democrat Government that had approved expanded nuclear energy use in the 1975 energy program. The Center Party, the leading party of the new coalition government, looked to conservation as one alternative to nuclear energy and continued to push these elements of the 1975 program. With the withdrawal of the Center Party from the coalition in October 1978 because of its refusal to compromise on the nuclear issue, nuclear development is now more likely to proceed as approved in the 1975 program; but conservation has wide support in Sweden and should continue as a major national goal.

Savings by Sector, 1976 *

Residential/Commercial, Agricultural, and Public Services Sector

Savings in the combined residential/commercial, agricultural, and public services sector amounted to an estimated 35,000 b/d of oil equivalent in 1976, with consumption 11 percent below what it would have been had the 1969-73 trend persisted. Energy consumption per building decreased by an average 0.7 percent per

* See Appendix for methodology.

SECRET

year between 1974 and 1976. As in France, Japan, and Canada, relative savings in this sector were at least twice the savings in any other sector. Many countries concentrate energy conservation efforts in this sector because they believe the greatest energy-saving potential exists in reducing energy used for space heating in buildings.

The savings reflect increased fuel costs and higher energy taxes, the weighted average price for fuel consumed by this sector having increased 40 percent between 1974 and 1976. The price of heating oil, which supplies 85 percent of residential energy requirements, increased 50 percent during the period.

Stockholm hopes to achieve still greater savings in space heating, which represents 90 percent of all energy use in this sector. State retrofitting programs for improvement in building energy efficiency cost \$342.3 million * in the residential portion alone between mid-1974 and mid-1978. These programs provide 20-year low-interest loans and up to \$700 in grants for each dwelling for insulation improvements, and grants of up to 35 percent of the cost for improvements in commercial buildings.

Based on a study conducted by the National Board of Physical Planning and Buildings, a bill has been presented to Parliament substantially increasing loan and grant programs for existing dwellings and commercial buildings. The Board estimates that an expenditure of \$18.4 billion to \$20.7 billion for retrofitting over a 20-year period could eventually save as much as 300,000 to 350,000 b/d of oil equivalent. This program appears overly ambitious given current and projected budgetary constraints.

A retrofitting program in the public services portion of this sector decreased energy consumption by about 15 to 20 percent per year between mid-1974 and the end of 1976, according to Physical Planning and Building Board estimates. Stockholm spent \$39 million on this program between mid-1974 and mid-1978. In 1976 Stockholm set maximum temperatures of 20°C for public buildings and imposed restrictive electricity use standards.

Taxes on electricity used for space heating were tripled between September 1975 and March 1977, and the State Power Board recently imposed an 18 percent rate increase for households having electric heat. Stockholm is also considering banning installation of electric heat where district heating exists or is planned.

In January 1977, Stockholm legislated building standard regulations for structures constructed or extensively renovated after July 1977. The regulations, which are expected to increase construction costs by 5 percent, aim for a 40 percent improvement in energy performance through:

* All conversions are based on the average 1976 exchange rate of US \$1=4.3559 Swedish kroner.

SECRET

- A toughening of insulation standards.
- Automatic control devices to regulate and improve distribution of energy and/or air flow.
- Waste heat recovery.
- Increased boiler efficiencies.
- Unit metering of utilities in multifamily dwellings.
- Manuals for optimum building utility management.

The State Planning Board has recommended mandatory government inspection of buildings to enforce the regulations.

Industrial Sector

Savings in the industrial sector were an estimated 10,000 b/d of oil equivalent in 1976; consumption was 3 percent below the level suggested by preembargo trends. Savings as a percent of industrial energy consumption in this sector were less than in West Germany, Japan, and Canada, but were equal to or slightly higher than in the United Kingdom, Italy, and France. Higher energy costs and government conservation measures were the primary incentives. The weighted average price of fuel used by the industrial sector increased 100 percent between 1974 and 1976; oil supplies almost half of industrial energy requirements. Output declined in the major energy-intensive industries—pulp and paper, iron and steel, chemicals and petrochemicals, and cement.

Government conservation efforts in this sector have eschewed tough energy pricing and taxation policies in an attempt to avoid further deterioration of industry's weakened export position. Energy-intensive industries are protected by regulations limiting energy taxation to less than 3 percent of the product sales value; 175 industries have been exempted entirely from taxes on oil, electricity, and coal although plans are being considered to reduce such exemptions.

Stockholm uses grants to encourage industry to accelerate energy efficiency modifications that otherwise would be deferred until energy prices rise to the level necessary to make such conversions economical. Between mid-1974 and mid-1978 grants totaling \$121 million were provided to industry. Stockholm also requires government approval for siting new energy-intensive industries as a means of controlling industrial energy use.

SECRET

Transportation Sector

In 1976 the transportation sector saved an estimated 2,000 b/d of oil equivalent, or 2 percent less than it would have consumed based on preembargo trends. Energy savings relative to consumption in this sector trailed those of five of the six major foreign industrial countries previously examined.

The savings reflect higher fuel prices, a 22 percent increase in gasoline taxes between late 1973 and 1976, and government actions to encourage the use of smaller cars and public transportation. Between late 1973 and 1976 gasoline prices increased 55 percent; in 1976 a gallon of regular gasoline cost \$1.43, half of which was tax. The average annual amount of gasoline consumed per vehicle declined at an average annual rate of 1.8 percent between 1974 and 1976, faster than during the preembargo period. Road transportation accounts for about 85 percent of energy use in this sector.

Stockholm also has continued policies in effect prior to the embargo to encourage energy efficiency in the transportation sector. These include vehicle efficiency standards, speed limits of about 90 to 110 kilometers per hour (55-70 miles per hour) steep purchase taxes, annual weight taxes on vehicles, elimination of free parking in cities, high parking fines, mass-transportation lanes, and streets restricted to pedestrian use.

Energy Sector

No savings were obtained in the energy sector. Indeed, energy efficiency trends deteriorated between 1974 and 1976 in electricity generation and petroleum refining. Electricity conversion loss accounts for roughly 75 percent of energy consumption in this sector. The amount of energy used per unit of electricity output increased at an average annual rate of 0.9 percent between 1974 and 1976. This trend stems mainly from a rapid increase in nuclear power which in Sweden has been less efficient than thermal power. From 1973 to 1976 the share of nuclear power in electricity generation rose from 3 percent to 18 percent.

Waste Heat Utilization

Stockholm hopes to reduce energy conversion losses through greater use of waste heat from industrial complexes and combined electricity and heat (cogeneration) plants. Waste heat currently supplies 20 percent of total residential space heating through district heating networks. Stockholm projects waste heat availability of about 70,000 b/d of oil equivalent by 1990 from the major industrial energy consumers—the pulp and paper, iron and steel, and chemical industries. During the past year Stockholm substantially increased long-term state loans to municipalities for develop-

SECRET

ing district heating networks and grants to homeowners for linkups to existing district heating systems.

The National Industrial Board conducted two studies in 1976 and 1977 on energy savings through use of back-pressure turbines for energy-intensive industries.* The studies projected that, at a cost of \$528 million, 20 percent of total industrial oil consumption, or about 8 percent of total industrial energy use, could be saved over a five-to-ten year period by subsidizing up to 35 percent of the cost of industrial

Sweden: Conservation R&D Budget

	Million US \$	
	1975-78	1978-81
Residential/Commercial, Public Services, and Agriculture	12.0	35.6
Industrial	8.3	19.7
Transportation	6.4	7.3
Total	26.7	62.6

conversions to back-pressure power generation and other energy-efficient processing modifications. Because industrial electricity tariffs are relatively low, purchased power can be more economical than self-generation in back-pressure systems. Stockholm, therefore, is considering supplemental loans to make such a major energy-saving expenditures more attractive to industry. In late 1977, the State Power Board also raised industrial electricity rates by 25 to 35 percent.

Outlook

Prospects are good for Sweden to improve its energy-use efficiency, and policy emphasis is likely to continue to be placed on conservation. Sweden is currently developing an energy program for the 1980s scheduled to be presented to Parliament early in 1979.

New conservation measures under consideration include:

- Expansion of district heating using heat generated by nuclear and peat sources.
- State grants for solar-heated homes and obligatory use of solar energy for other specified applications.

* Back-pressure systems can produce steam at sufficiently high temperatures after generation of electricity to serve as the heating medium in industrial processes and, when spent, as input to district heating networks.

SECRET

- Reduction in the number of private motor vehicles by imposing higher taxes and fees.
- Tax breaks for light cars.
- Transition to new fuels and engines with better gas mileage, encouragement of carpooling, staggered commuting patterns to avoid traffic tieups, and resumption of trolley bus service.
- More efficient street lighting and restrictions on electricity use.
- Control of energy used for luxury items, such as a ban on the use of oil for heating vacation homes and mandatory solar heating for swimming pools.

Stockholm believes annual energy consumption growth will be cut to 2 percent by 1985. The Swedish Ministry of Economy now anticipates that by 1985 annual GNP will be growing at about three-fourths the projected rate of 3.5 to 4 percent in the 1975 energy plan. Moreover, an expected lag in the growth of energy-intensive industries, retrofitting of existing buildings, and the impact of the 1977 bill to improve energy efficiency in new buildings are expected to hold energy use growth below the earlier forecasts.

APPENDIX: Methodology

Savings Record by Sector

Our estimate of energy savings from conservation—47,000 b/d of oil equivalent in 1976—is derived by subtracting actual energy consumption in each of four economic sectors from estimates of what energy consumption would have been if pre-1973 relationships had continued through 1976. These 1973 relationships are:

- In the residential/commercial, agricultural, and public services sector, the equation for energy use per dwelling as a function of real disposable income and temperature is

Log of (residential/commercial, agricultural, and public services energy use ÷ housing stock) = 12.15980 + 0.29626 (log of real disposable income) + 1.27295 (log of degree-days).

- In the industrial sector, the equation for industrial energy use as a function of industrial output and temperature is

SECRET

Log of industrial energy consumption = $9.94172 + 1.01476 (\log \text{ of industrial output}) + 1.27295 (\log \text{ of degree-days})$.

- In the transportation sector, the equation for energy use as a function of registered motor vehicles and real disposable income is

Log of transportation energy consumption = $0.80626 (\log \text{ of real disposable income}) + 0.22638 (\log \text{ of registered motor vehicles})$.

- In the energy sector, the relationship of energy consumption to final energy use is

Log of energy consumption = $- 2.75729 + 1.32526 (\log \text{ of final energy use})$.

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